Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	
Unlicensed Operation in the TV Broadcast Bands	ET Docket No. 04-186
Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band	ET Docket No. 02-380

COMMENTS OF MOTOROLA, INC.

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SUMMARY

Motorola supports the Commission's efforts to allow unlicensed operations on vacant channels in the broadcast TV spectrum below channel 52, as long as incumbent operations are fully protected. With the exception of broadcast channels 14 to 20 that are already being shared with public safety and commercial mobile radio services, the Commission should approve unlicensed operations on most of the other channels identified in the NPRM. The FCC should also coordinate with NTIA to determine any impact of potential unlicensed operations on TV channel 7 (174-180 MHz), since this channel is directly adjacent to the 162-174 MHz band which supports primary mission critical communications for Federal law enforcement. Licensed mission critical operations, whether local, state, Federal or private must be fully protected.

Motorola agrees with the Commission that geolocation and control signal transmission are acceptable means for identifying open TV channels for unlicensed transmissions. Spectrum sensing, on the other hand, is an unproven technology that must be closely reviewed and fully tested before it is authorized.

Motorola offers several clarifications and some modifications to the proposals in the NPRM. Rather than mandate use of a particular location technology, the FCC should specify a location reliability parameter, which will encourage innovation in the field of location technology. In addition, channel availability information sent to fixed and handheld units must be in a standard format and include a validity period for which the channel is available. The

device must also include fail-safe methods to cease operation if the control signal is lost or database information cannot be updated.

Motorola conducted several analyses based on the technical parameters proposed in the NPRM and determined that: (i) the proposed out-of-band emissions levels may not provide adequate protection to TV receivers within the protected contour; (ii) both fixed and portable unlicensed devices should be required to comply with adjacent channel interference protection requirements; and (iii) the possibility of DTV receiver overload should be considered. These results are fully discussed in the attached appendices.

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Motorola, Inc. ("Motorola"), respectfully submits these comments on the FCC's Notice of Proposed Rulemaking in the above-referenced proceedings.[1] Motorola supports the Commission's approach to promote use of the TV broadcast bands by unlicensed devices on most channels below channel 52 while ensuring that incumbent operations are not impacted. The FCC should adopt the proposals in the NPRM, subject to the modifications and clarifications discussed herein.

Unlicensed access to unused TV broadcast channels would provide additional resources to realize seamless mobility, whereby users' communications travel seamlessly across conjoining user domains – from home to car, to the metro, to the office and beyond – with the transition between networks transparent to the user.[2] The proposed rules will enable the development of

[1] *See* FCC 04-133, rel. May 25, 2004, ("NPRM").

[2] *See* Motorola Makes Seamless Mobility Real, Company announces world's first integrated, dual-network phone, slimmest clam, Apple iTunes™ alliance, home remote control,

novel applications for handheld units and in-home wireless delivery. Moreover, the broadcast TV spectrum is particularly attractive for delivering wireless broadband services to rural areas because the propagation characteristics of these lower frequency signals exhibit enhanced coverage and building penetration in comparison to higher frequency ISM or U-NII equipment.[3] Thus, wireless broadband providers, *e.g.*, Wireless Internet Service Providers ("WISPs"), will be able to cover wider areas. The NPRM is fully consistent with the mandate of the Communications Act to support "efficient and intensive use of the electromagnetic spectrum,"[4] as well as the recommendations of the FCC's Spectrum Policy Task Force to provide enhanced "spectrum access and flexibility in rural areas."[5]

Motorola agrees with the Commission's general conclusion that it is technically feasible to have low-power unlicensed devices share spectrum with incumbent broadcasters without causing harmful interference to TV reception.[6] However, unlicensed underlay operation in TV spectrum that is presently shared by commercial and public safety land mobile operations should not be permitted until mechanisms that ensure interference-free unlicensed transmissions are

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(Continued)
his-and-hers TV, and fingerprints-on-demand, July 27, 2004, *available at* http://www.motorola.com/mediacenter/news/detail/0,,4494_3827_23,00.html. *See also* Ginny Parker, *Race to Link Wi-Fi, Cellphones Picks Up Speed*, WALL ST. J., Aug. 12, 2004, at B4.

[3] *See* NPRM ¶ 14 ("[T]he propagation characteristics of the spectrum occupied by the TV service would allow the design and manufacture of new types of unlicensed wireless broadband devices that could serve applications that need a greater range of operation and coverage than that afforded by unlicensed devices operating in higher frequency regions of the spectrum.").

[4] 47 U.S.C. § 309 (j)(3)(D). *See also* 47 U.S.C. § 303(g).

[5] FCC Spectrum Policy Task Force Report, ET Docket No. 02-135, Nov. 2002, at 6, 58-60.

[6] *See* NPRM ¶¶ 7, 15.

proven reliable. Thus, the FCC should not permit unlicensed operations on TV channels 14-20, *i.e.*, 470-512 MHz.[7] Allowing unlicensed operations in this spectrum could negatively impact the future growth of critical public safety services and other mission critical private wireless operations.

As Motorola explained previously,[8] predicting the interference levels and the impact of an aggregation of unlicensed transmissions at a victim receiver through spectrum measurements is a very difficult problem. Thus, further research and testing is necessary before unproven techniques such as spectrum sensing are implemented. We believe the other mechanisms proposed by the Commission based on location-specific databases can provide adequate interference protection to non-mission critical services and avoid the potential for unintended interference. Motorola has analyzed the FCC's proposed technical parameters, and has determined that interference could result even with the mitigation techniques and low power levels. *See* Appendices A and B. Thus, some modification of the proposed technical parameters is necessary.

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7 *See* NPRM ¶¶ 35-37.

8 *See* Comments of Motorola, Inc., ET Docket No. 03-237, Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile, and Satellite Frequency Bands, filed Apr. 5, 2004, at 8-14.

I. The Commission Should Designate 76-88 MHz, 174-216 MHz, 512-608 MHz And 614-698 MHz For Unlicensed Use.

A. Unlicensed Operations in These TV Channels Will Serve The Public Interest.

The Commission should allow unlicensed operations in the available broadcast TV spectrum that is currently used primarily for fixed broadcast operations, specifically, 76-88 MHz, 174-216 MHz, 512-608 MHz and 614-698 MHz. Unlicensed spectrum in these bands will enable robust wireless broadband deployments in rural areas and high-speed connectivity to the home.

Motorola's review of the spectrum blocks proposed by the Commission indicates that the greatest potential for open spectrum is at 614-698 MHz on TV channels 38 to 51.

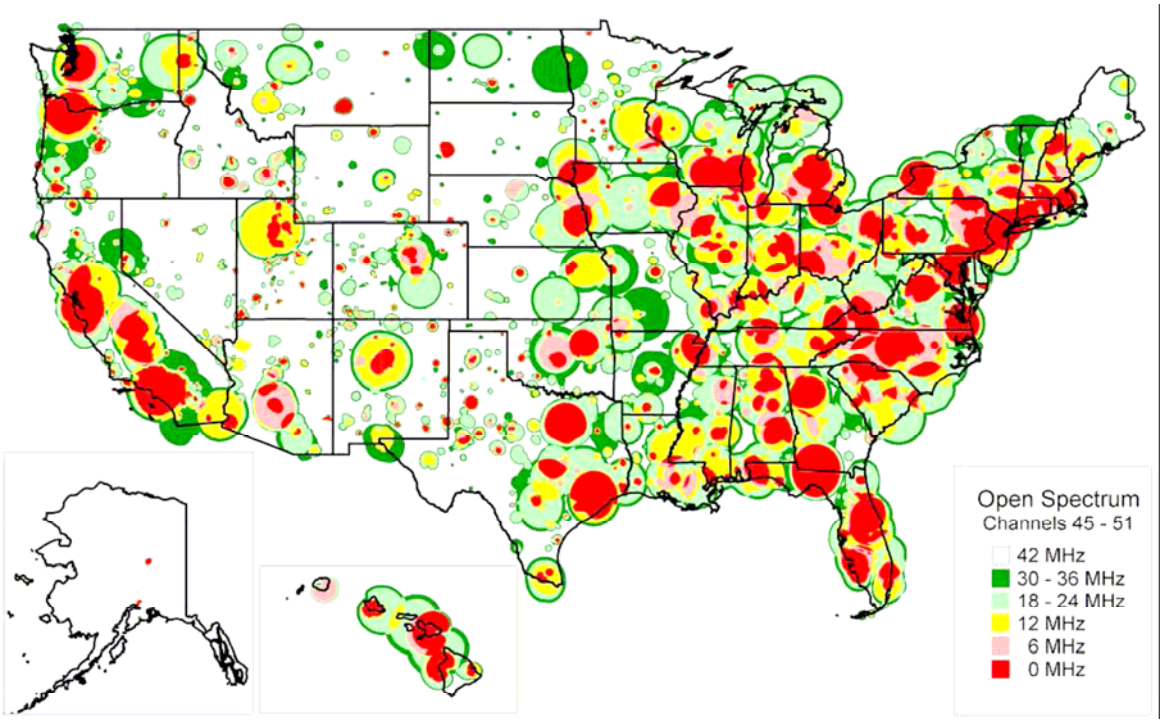

Figure 1. Estimated Available Spectrum for Unlicensed Operations on Channels 45 to 51[9]

[9] Figure 1 was created from FCC grade B data for Analog TV, Digital TV, LPTV, TV Translators, and Booster Stations, http://www.fcc.gov/oet/info/maps/mmb/, downloaded June 16,

Figure 1 is a color graphic depicting the estimated available spectrum on channels 45 to 51. While there is little available spectrum in major metropolitan areas due to the higher concentration of broadcast stations, there is considerable opportunity in rural locations with a minimum of 3 to 4 of the 7 channels available for broadband service. The opportunity for in-home wireless transmissions is likewise limited in major metropolitan areas. In rural and remote areas where there is open spectrum, the FCC should consider higher-powered unlicensed fixed operations up to 25 W as long as they comply with all interference protection requirements of the licensed services, especially adjacent channel D/U requirements and receiver overload considerations as discussed herein. Allowing higher power fixed operations will allow WISPs to provide service more cost effectively and over larger areas. This will increase options for the cost effective competitive delivery of rural broadband services.

B. Unlicensed Operations Should Not Be Allowed on TV Channels 14 to 20.

Any new unlicensed operations must provide full protection to both current and potential future licensed operations. In this regard, Motorola opposes the NPRM's tentative plan to allow unlicensed operations on TV channels 14 to 20, *i.e.*, 470 to 512 MHz, which are currently used for public safety and land mobile operations (*i.e.*, PLMRS/CMRS) and broadcast TV operations. Unlicensed underlay operation in TV spectrum that is presently shared by public safety and other

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2004. The map is created by extending the grade B contours in the fashion prescribed by the *NPRM* so that an unlicensed device operating at full power would meet the D/U requirements (both co-channel and adjacent channel) required for protection of TV operations. We note that this is a conservative estimate of the geographic picture for available spectrum since it does not include areas inside of the grade B contours where the desired signal is high.

critical private and commercial land mobile operations should not be permitted until mechanisms that ensure interference-free unlicensed transmissions are proven to be reliable to the degree necessary to fully protect mission critical operations. Where mission critical operations are involved, the consequences of interference are simply too great to be remedied after an interference event has occurred.

Authorization of unlicensed operations on channels 14 to 20 could impact the ability of public safety and private licensees to expand current systems to meet critical safety-of-life needs.[10] In recently granting such a waiver in the New York area, the Commission found that:

> The resolution and grant of the applications will fulfill the public safety agencies' needs for more channel capacity and *allow otherwise unused spectrum to be used for public safety communications*. The Proposal promotes intense and efficient use of this scarce spectrum through frequency reuse where geographic separation permits and a systematic frequency assignment approach of standard, three-megahertz channel pairing.[11]

Given that there is other spectrum available in the TV bands for unlicensed use, the Commission should reconsider its tentative proposal to permit unlicensed operations on spectrum that is currently being used for public safety services and other critical infrastructure industries. Preserving the option for Part 90 users to access the 470-512 MHz band will serve the public interest as it will promote interoperability with existing systems and allow for system expansion.

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[10] Search of the FCC ULS database indicates that there are 5558 Part 90 Land Mobile active licenses in the 470-512 MHz band.

[11] *See* Seven Public Safety Agencies In The New York Metropolitan Area, *Order*, DA 04-2496, rel. Aug. 10, 2004, ¶ 18 (emphasis added) (granting public safety agencies' proposal to use frequencies designated under Part 22 as paging control and trunked mobile channels to support expanded and extensive communications requirements).

C. Potential Unlicensed Use on TV Channel 7.

Prior to any decision to allow unlicensed operation on channel TV channel 7 (174-180 MHz), the FCC and NTIA should coordinate to ensure that such operation would not interfere with Federal operations in the 162-174 MHz spectrum directly adjacent to TV channel 7. The 162-174 MHz band is the primary frequency band for Federal law enforcement land mobile communications systems and requires protection from unlicensed devices similar to that advocated above for non-federal government mission critical communications.

II. FCC Rules Must Protect Current And Future Licensed Uses.

The Commission must ensure that any interference avoidance mechanisms prevent harmful interference to licensed incumbents.[12] Motorola has analyzed the FCC's proposed technical parameters that govern the interference avoidance mechanisms and has determined that even for more reliable mechanisms, such as those employing control channel transmissions and geolocation/database lookup, there is still some potential for unintended interference in certain cases. Motorola describes its analysis in the following sections and provides additional details in Appendices A and B to these comments.

Other techniques mentioned in the NPRM for finding unused channels, most notably spectrum sensing, are promising but unproven. Predicting the interference levels and the impact

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[12] Unlicensed operations should also be secondary to Part 74 auxiliary broadcast operations such as wireless microphones. *See, e.g., Notice of Ex Parte Meeting Meeting,* Shure, Inc., ET Docket No. 04-186, submitted Aug. 5, 2004. Given the operational nature of these devices, different mitigation techniques may be required to combat interference such as low power control signals, more frequent database updates or more sensitive spectrum sensing techniques. *Id* at 18-25.

of an aggregation of unlicensed transmissions at a victim receiver relying only upon spectrum measurements is a very difficult undertaking. It would be premature to rely on spectrum sensing until these mechanisms are shown to be reliable via comprehensive study and real-world testing.

A. Control Signal Transmission and Geolocation Are Acceptable Mechanisms For Identifying Open Channels For Unlicensed Operations.

Low-Power Operations. The FCC proposes allowing low-power personal/portable broadband devices to transmit only after they receive a control signal positively identifying vacant TV channels to ensure that the devices operate only on unused spectrum. Motorola believes that it will be difficult to restrict very-wide coverage area radiated control signals to the intended region. At a minimum, detailed system simulation studies and experimental verification are needed to demonstrate that personal/portable control signals can be constrained by application of worst-case path loss modeling, including transmit antenna height above average terrain ("HAAT"), portable antenna gain, portable antenna height above ground level ("HAGL"), and sensitivity assumptions. When determining the permitted unlicensed coverage area, consideration of signals emitted by the portable unlicensed unit also must be taken into account, with similar worst-case propagation assumptions that include expected portable antenna height and maximum EIRP.

Fixed Operations. The Commission proposes allowing fixed unlicensed devices with 4 Watt EIRP that either: (i) incorporate a GPS receiver to determine device location and then access a database and software program to determine the vacant channels at the location; or (ii) are installed by a professional who will determine the vacant channels at the device's

location, by accessing the same database and software interface, either directly or through a third party.[13] In developing the database that will identify the vacant channels, Motorola recommends that the HAAT of the fixed/access base station antenna and HAGL for the fixed/access subscriber antenna be used in the interference assessment. Unlicensed devices operating at significantly higher HAAT or HAGL than what is used to compute open channels for such a method would result in higher levels of interference to licensed operations than predicted.

Devices operating with control signals or geolocation mechanism must have a fail-safe mode which will cease operation when the control signal is lost or the database information become invalid.

1. Rules Should Specify Location Reliability, Rather Than Require a Specific Location Technology.

Motorola recommends that rather than specify a location technology such as GPS, the Commission should specify location reliability. Such an approach would spur innovation by encouraging the development of location technologies that provide the requisite level of certainty.

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[13] *See* Proposed Rule Section 15.244(e); NPRM ¶ 26. The Commission should clarify what is meant by "professional installation." Motorola urges the FCC to require that the installation be supervised and/or inspected by a NARTE (National Association of Radio Telecommunications Engineers) Certified EMC (Electromagnetic Compatibility) Engineer, an SBE (Society of Broadcast Engineers) Certified Broadcast Radio or Television Engineer, FCC Commercial License Holder, or a Registered Professional Engineer. The professional installer must determine that the installation will operate in compliance with all FCC Rules adopted for this service, in particular that the unlicensed transmissions will not cause interference to licensed operations.

2. Channel Availability Information Should Be In a Standard Format and Updated Regularly Through Authorized Database Registration.

Both low-power and fixed unlicensed devices which rely on a database to locate vacant channels on which to transmit must be able to update periodically the channel availability information and modify their operation accordingly.

The channel availability information provided to both portable and fixed devices via a control signal also would need to be in a standard format so that devices can process the information automatically. The standard format should include a security mechanism to ensure the authenticity and integrity of the database information. Otherwise, unlicensed devices could be used as unwitting accomplices in denial-of-service attacks against licensed users, or be unfairly denied access to a vacant channel. Furthermore, a validity period should be included with any information sent out from a database. If the unlicensed device does not refresh its information from the database before the validity period expires, then the device must cease operation.

3. Third Party Providers Of Database Information Should Be Responsible For Its Accuracy.

Third party providers of vacant channel information (*e.g.*, a frequency coordinator, industry association, local broadcast group) should be held liable for the accuracy of the data. Both users and suppliers of unlicensed devices will rely on the information, as they ultimately are liable for the interference they cause to licensed services.[14] Since third parties normally rely

[14] *See* NPRM ¶ 26.

on the Commission database as a source of information, the FCC would also bear some responsibility to ensure its database accuracy.

B. Some Modifications to the Proposed Rules Are Warranted.

Motorola has conducted a number of analyses based on the technical parameters proposed in the NPRM, which show that several modifications to the proposals are needed. First, additional out-of-band emissions requirements may be needed to provide protection to licensed services as the Section 15.209(a) out-of-band emissions may not meet protection requirements for television operations in all cases. Second, both fixed and portable unlicensed equipment should be subject to adjacent channel protection requirements; the NPRM suggests that portable units only need to be subject to the co-channel criteria. Last, any promulgated rules must account for DTV receiver overload.[15]

In Appendices A and B, Motorola explains that while an allowable EIRP that satisfies the desired to undesired ("D/U") ratios with a given confidence can be determined, many factors need to be taken into account, such as antenna polarization discrimination, antenna pattern, and population density. The results of recommendations from Motorola's analyses, which are presented in the two appendices, are summarized in the following sub-sections.[16]

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[15] There also is a potential for unlicensed emissions to overload the front-end of a nearby DTV receiver. The ATSC recommends that a DTV front-end should tolerate an input level of -8 dBm.(*ATSC Recommended Practice: Receiver Performance Guidelines*, Advanced Television Systems Committee Doc. A/74, June 18, 2004). The Commission should fully review this issue recognizing that the potential for receiver overload heavily depends on the scenario considered.

[16] These recommendations are based on a representative suburban lot size, and so would be overly strict for rural use but perhaps inadequate for urban use. Also, the analysis is based on a single transmitter – not multiple transmitters – and because multiple devices could be operating

1. The Proposed Out Of Band Emission Limits Do Not Meet D/U Requirements for Protection of TV Operations in All Cases.

The Commission proposes that the out-of-band emissions from unlicensed devices comply with the levels specified in Section 15.209(a).[17] However, this level does not comport with protection requirements for television operations. Motorola's technical staff has performed a number of analyses to determine the D/U interference impact of out-of-band emissions for a nearest neighbor scenario assuming both co-polarized and cross-polarized unlicensed transmitters for rooftop mounted (*i.e.*, fixed) operations. A summary of the analysis is provided in Appendix A to these comments.

The analysis finds when operating inside a grade B contour with co-polarized unlicensed devices, the out-of-band emissions at Part 15.209(a) levels would, under worst-case conditions, exceed the FCC specified D/U required field strengths by over 35 dB. The use of a more conservative Monte Carlo analysis indicates that the Part 15.209(a) field strength levels exceed the specified D/U requirements by over 16 dB.[18] Based on the scenarios analyzed, we believe that Part 15.209(a) emission levels do not provide adequate protection to TV receivers within the protected contour and further analysis is warranted.

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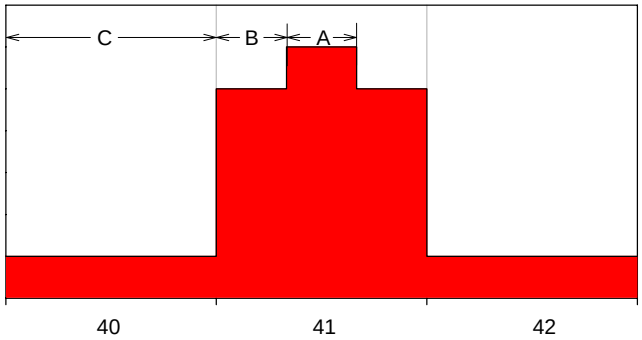
within a TV channel without interfering with each other, the interference potential could be underestimated. This particular aspect warrants further study.

[17] *See* NPRM ¶ 39.

[18] The respective Part 15.209(a) field strength shortcoming to meet D/U requirements is dependant upon the scenario considered. *See* App. A.

2. Changes in the Emission Mask Would Facilitate Deployment.

For devices constrained to operate on a single TV channel, a reduction in bandwidth will be required to accommodate the spectral regrowth due to power amplifier non-linear behavior. Motorola estimates that in order to comply with out-of-band emissions levels in TV channels immediately adjacent to the operating channel of the unlicensed device, that the maximum practical signal bandwidth, for a full powered device, that can be utilized in that channel would be 2 MHz, essentially requiring a guard band of 2 MHz on each side of the signal.[19] The problem is shown in Figure 2 below.



A: Main emissions of the device
B: Outside the bandwidth of the device but in the TV broadcast channel the device operates (-20 dB)
C: Outside of the TV broadcast channel where the device operates (15.209(a))

Consider emission bandwidth of device to be 2 MHz with EIRP of 4 W

- EIRP density = 23 dBm/100 kHz (assuming flat spectrum)
- Region B: Emission level required to be 3 dBm/100 kHz
- Region C: Emission level required to be -49 dBm/100 kHz
- Attenuation of 72 dB

Figure 2. Out-Of-Band Emissions Levels

A practical alternative for increasing the usable bandwidth of a device would be to permit the manufacturer to declare the operating bandwidth, outside of that bandwidth the device would

[19] This assumes that non-linear effects higher than third-order will fall below the out-of-band emission requirements.

have to comply with the out-of-band emissions levels required to protect TV operations.[20] This approach would provide manufactures flexibility in meeting the out-of-band requirements for protection of licensed operations.

3. All Unlicensed Devices Should Be Subject to Compliance With Adjacent Channel Protected Contours.

The NPRM proposes that personal/portable devices be subject only to the co-channel protection criteria.[21] However, to ensure continued protection of TV operations, portable devices also should be subject to the adjacent channel D/U requirements, as is required for fixed/access devices. When a portable device operates inside a protected contour on an adjacent channel, Motorola suggests that the maximum transmit power be reduced to comply with the adjacent channel D/U requirement. For an example shown in Appendix B, the maximum permitted EIRP is -17 dBm for Low VHF, -9 dBm for Upper VHF, and -4 dBm for UHF.

As mentioned previously, Federal operations in spectrum adjacent to TV channel 7 need to be protected from any contemplated unlicensed operation in the 174-180 MHz band. We note that unlicensed broadband operation underlay on TV channels 13 (210-216 MHz) may also impact land mobile operations in portions of the 216-222 MHz band.

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[20] For example, consider a device with a 3 dB bandwidth of 6 MHz. If the manufacturer requires an additional 3 MHz beyond the 3 dB bandwidth of the device to comply with the out-of-band emissions levels then the declared operating bandwidth would be 12 MHz. The device would have to find two contiguous unused channels for operation. This essentially requires any guard band to meet the out-of-band emissions levels to be taken from the spectrum available to the unlicensed device.

[21] *See* NPRM ¶ 31.

C. While Spectrum Sensing Shows Promise For Identifying Open Channels, Further Studies Must Be Conducted.

With fixed/access unlicensed systems, knowledge of the unlicensed device's and TV broadcast tower's transmitter parameters (*e.g.*, coordinates, HAAT, EIRP) and incumbent receiver sensitivity (including antenna gain and HAGL) allow for the computation of interference contours. Personal/portable systems are presumed to not have reliable location information available, but by virtue of their detection of a control signal and worst-case propagation losses of their own signals, their emissions are required to fall below specified levels at the protected contours.[22]

Ingress of interference from outside of a contour can be controlled by way of these mechanisms. However, interference from within the contour on adjacent or other channels is another matter. The NPRM accounts for the adjacent channel by requiring the fixed/access unit to estimate the pessimistic F(90,90) incumbent signal strength at its location (or the protected contour strength, whichever is greater) and to adjust its transmissions accordingly.

Spectrum sensing as a means of determining spectrum opportunities is a possibility raised in the NPRM.[23] However, it is unclear how a spectrum sensing device could determine the

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[22] This may require that the control signal indicate a maximum EIRP versus channel number in the list of open channels.

[23] *See* NPRM ¶ 28.

impact of its emissions without knowledge of its proximity to the contour.[24] This impacts transmissions on both the co-channel and the adjacent channel.

Motorola believes the burden of presenting convincing evidence of the reliability of spectrum sensing technology under a wide variety of environments and conditions should be on the proponents of the technology. Although the technology appears promising, Motorola recommends that the Commission support further experimentation with the technology, but not permit spectrum sensing until its reliability is proven. Instead, the Commission should actively pursue the control channel and geolocation interference control mechanisms.

D. Registration of Unlicensed Infrastructure With A Frequency Coordinator Will Aid Enforcement.

Motorola supports registration of fixed/access base stations and personal/portable beacon transmitters with a frequency coordinator to aid enforcement and enable identification of interfering devices. Subscribers to the base station should be exempt from registration since their transmissions are controlled by the base station. However, Motorola opposes the proposal to require the low power personal devices to periodically transmit an identification signal.[25] The interference protection mechanisms proposed by the FCC (*i.e.*, geolocation and control channel) and registration of unlicensed infrastructure with a frequency coordinator provides sufficient interference protection. Specifically, an unlicensed device will not be permitted to transmit until

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[24] We understand that proximity can be inferred from sensed power measurements, but the reliability of this method requires further study.

[25] *See* NPRM ¶ 22.

it receives vacant channel information, and then may transmit only on those channels through coordination with the infrastructure.[26]

E. The FCC Should Not Limit Technology.

The Commission should support the development of voluntary standards for unlicensed operations in the TV bands, yet it should not regulate compliance with a particular interoperability standard.[27] In this way, the Commission will not rule out innovative uses of the band by non-standards based approaches.

Thus, the FCC should only specify minimum operating requirements to enable shared use of the bands, as it has sought to do in proposed rule section 15.244, and let voluntary standards bodies (like IEEE 802) set interoperability guidelines.[28] This is the same approach that the agency successfully implemented with unlicensed operations at 2.4 GHz and at 5 GHz.[29]

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[26] *See* Proposed Rule Section 15.244(e) and (f).

[27] *See* NPRM ¶ 47. Once the FCC puts the baseline interference protection requirements in place, the agency will need to implement test procedures to verify device compliance with the new database-dependent control signal rules. *See* NPRM ¶ 45.

[28] *See* U-NII Report and Order ¶ 29 ("[V]oluntary standards-making bodies, like IEEE, routinely update their standards to reflect Commission requirements.").

[29] The success of this approach is borne out by the unprecedented growth of Wi-Fi networks, enabled by the FCC's light regulatory touch and industry-led standardization. *See* Jane L. Levere, *Business Travel, Wi-Fi Service Expands Its Reach*, N.Y. TIMES, July 27, 2004 ("[T]he number of public hot spots in the United States already surpasses 10,000 and is likely to reach 65,000 by 2008.").

III. Conclusion.

Motorola recommends that the Commission authorize the proposed operations, with the modifications describe above, in the TV broadcast spectrum that is currently used by fixed broadcast services. The FCC should not, however, permit unlicensed operations at 470 to 512 MHz (*i.e.*, channels 14 to 20) because broadcast TV stations already share this spectrum with private land and commercial mobile radio services. Allowing unlicensed operations in these channels could impact existing operations and future growth of public safety services.

Motorola generally supports the FCC's proposals to increase the available unlicensed spectrum in open spectrum currently allotted for use by TV broadcast stations, subject to the limited set of modifications outlined above and covered in appendices to the comments. The proposed approach will enable the cost-effective delivery of broadband wireless solutions, particularly in underserved rural regions.

Respectfully submitted,

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APPENDIX A

ANALYSIS OF THE PROPOSED OUT-OF-BAND EMISSIONS LIMITS

I. FCC Rule Section 15.209(a) and EIRP

The NPRM proposes that the out-of-band emissions of the unlicensed radiators conform to Part 15.209(a) E-fields. For convenience, these levels are repeated in Table A1 below.[1] The E-field measurements are taken at 3 m with a CISPR-16 receiver, which is assumed to have a 100 kHz noise bandwidth.

Band	E-field Strength (μV/m)	EIRP (nW)
L-VHF	100	3
H-VHF	150	6.75
UHF	200	12

Table A1. Part 15.209(a) and corresponding EIRP.

The following equation shows the relationship between E-field strength and EIRP:

$$\frac{E^2}{\eta} = \frac{EIRP}{4\pi \cdot d^2} .$$

The out-of-band emissions could be a discrete spurious line, such as a synthesizer reference line or local oscillator leakage. More generally though, the out-of-band emissions could be a mixer or modulator image or a noise floor due to a D/A converter, IQ modulator, VCO or other synthesizer element, or power supply noise modulating the transmitter lineup in a variety of places. The EIRP in column 3 of Table A1 can be expressed as a power density in units of dBm/Hz. If the density is flat (as assumed here), then an EIRP for a 6 MHz bandwidth can be extrapolated.[2] *See* Table A2.

The 6 MHz-bandwidth EIRP is assumed for all of the following out-of-band emissions calculations. This flat out-of-band emissions region can become co-channel interference to any channel and so should satisfy proposed D/U levels. *See* Figure A1. A co-channel D/U value of 23 dB is assumed for the following analysis.[3] Note that for a full-power +36 dBm EIRP fixed/access emitter, the transmitter noise floor would have to be in the range of -135.2 to -141.2 dBc/Hz (*i.e.*, the relative level of the spectral density of Table A2, column 2 to +36 dBm).

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[1] *See* NPRM ¶ 39.

[2] The actual noise bandwidth of a DTV receiver is 5.38 MHz. This admits about 0.45 dB less noise than a 6 MHz bandwidth for a flat noise density.

[3] *See* NPRM ¶ 30 for DTV.

While noise floors achievable in practice are certainly better than this, noise floors in this range can result from shortcuts taken to develop low cost, low current circuits. Channel bandwidth selectivity at the output of the transmitter lineup would help matters; however, considering the wide range of frequencies being proposed for these systems, such filtering would have to be tunable over that range, and that filtering would now have to tolerate the transmitter power levels (1 W maximum). Again, such filters can be implemented but would preferably be substituted with simpler, switchable harmonic filters.

Band	EIRP Density (dBm/Hz)	EIRP (nW/6 MHz)
L-VHF	-105.2	180
H-VHF	-101.7	405
UHF	-99.2	720

Table A2. Power density for EIRP that generates Part 15.209(a) compliant E-fields, and the EIRP over a 6 MHz bandwidth assuming flat spectral density of the out-of-band emissions.

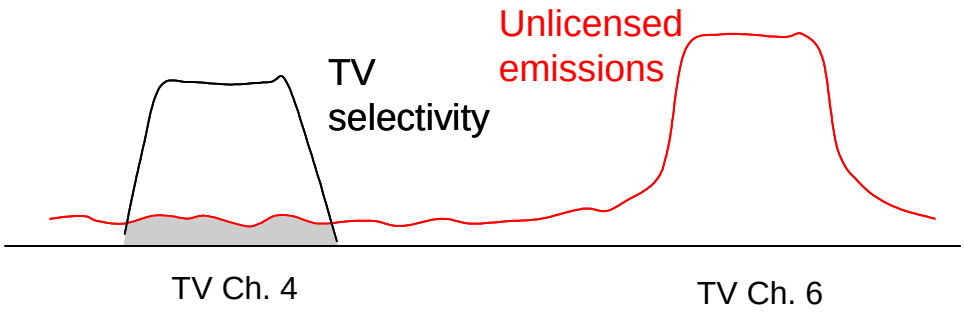

Figure A1. Unlicensed out-of-band emissions becoming co-channel interference for another channel.

II. Worst Case E-Field Strength

The NPRM implies a minimum range to a victim receive antenna of 10 meters.[4] Assuming the unlicensed emitter is fixed/access with a rooftop antenna, with emissions that are co-polarized with the victim TV antenna, and square law propagation for this short distance, the co-channel interference values shown in Table A3 result. These values exceed the proposed 23 dB D/U level at the protected contour field strength by the amount shown in the last column of the Table. The required E-fields are derived from the DTV protected contour strength[5] minus the 23 dB D/U level.

4 *See* NPRM n.50.

5 *See* NPRM ¶ 29.

Band	Co-channel E-field Strength (dBu)	Required E-field Strength to Satisfy D/U (dBu)	Excess Field Strength (dB)
L-VHF	47.3	5	42.3
H-VHF	50.8	13	37.8
UHF	53.3	18	35.3

Table A3. Interfering E-field strength at the victim TV antenna for worst-case range conditions. The required 23 dB D/U ratio is violated by 35 to 42 dB.

Table A3 indicates that Part 15.209(a) is inadequate by 35 to 42 dB. However, such a worst-case analysis, while possible, could be considered improbable for rooftop antennas on individual residences. For this reason, a statistical approach to the problem has been taken in section III.

III. Simulation Scenario For Statistical Analyses

Generally, the worst offender from an emissions standpoint will be a nearest neighbor to a victim receiver. This scenario is analyzed for the proposed out of band emissions levels. The analysis considers both co-polarized and cross-polarized unlicensed operation since polarization of the unlicensed units is not specified in the NPRM.[6]

A typical quarter acre suburban lot is assumed, with golden ratio aspect and 6 m wide streets. *See* Figure A2. A quarter acre is 10,890 ft^2. With a golden ratio aspect (1.618:1), the dimensions of the lot are 82 x 132.7 ft (25 x 40.5 m).[7] The houses are assumed to be 15 m long and centered in the lot, and a 6 m wide street separates across-the-street neighbor lots. The unlicensed transmit antenna is uniformly randomly located on the horizontal centerline of the central house, and may assume a uniform random azimuth direction for each Monte Carlo trial.

Each neighboring house has a victim TV antenna, all with the same uniform random azimuth direction (different from the direction of the unlicensed antenna), and all uniformly randomly located on the centerline of the houses. Note that this configuration allows a minimum offender-victim antenna spacing of 10 m, as suggested in the NRPM. The house with the unlicensed antenna is not allowed to have a TV antenna for this analysis, since the NPRM interference paradigm excludes interference under the TV viewer's control[8].

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[6] In fact, the words "polarized" or "polarization" are not to be found in the document. We recognize that it may not be fair to consider cross-polarization for unlicensed use in the long term, since this would limit future multi-path mitigation developments for DTV antennas which could include polarization diversity, circular polarization, or polarization-adaptive receive antennas. Such techniques could be useful for receiving elliptically-polarized transmissions.

[7] Some aspect ratio needed to be chosen; golden ratio is an arbitrary but familiar choice and representative of actual suburban lots.

[8] Again, *see* NPRM n.50. However, this could pose a problem for multi-residence dwellings such as apartments or town homes, where there may be a "community" TV antenna and a "community" unlicensed antenna on the same roof.

Both the offending unlicensed and victim TV antennas are assumed to be rooftop mounted for this analysis. This would be representative of a fixed/access deployment. Square law propagation is assumed for these short ranges (maximum range = 108 m). This assumption becomes progressively less valid for further removed neighbors with higher likelihood of an intervening rooftop intruding into the first Fresnel zone; however, rough calculations assuming knife-edge diffraction show less than 4 dB additional loss even in L-VHF for the furthest removed neighbor in this scenario. Bulk attenuators such as foliage are not included. The victim TV antenna is assumed to discriminate the incoming E-fields according to the $\cos^4\theta$ pattern down to a fixed side/back-lobe level suggested by the FCC for interference analysis.[9] See Figure A3 for a sample pattern. In some cases, the same main lobe pattern is assumed for the unlicensed transmit antenna.

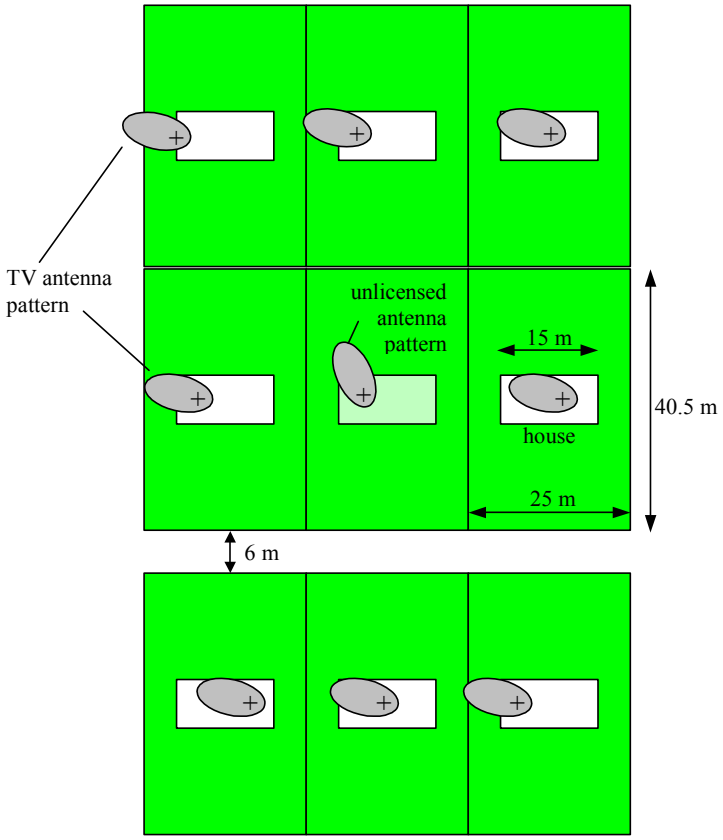

Figure A2. Portion of layout for nearest neighbor analysis. The full layout includes five columns and rows of lots, covering a total area of 125 m x 214.5 m.

[9] OET Bulletin No. 69, "Longley-Rice Methodology for Evaluating TV Coverage and Interference," Feb. 6, 2004.

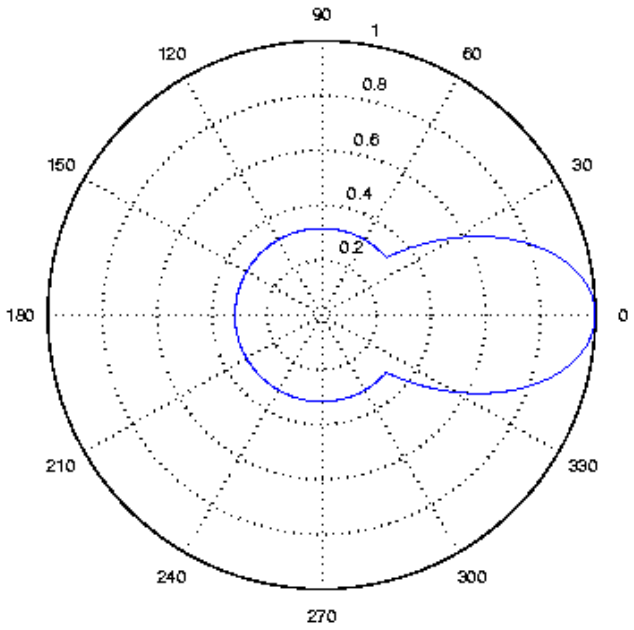

Figure A3. Sample TV antenna pattern from the OET-69 Bulletin. This case is for the L-VHF DTV pattern with 10 dB down side/back-lobes.

IV. Simulation Results

For the simulated environment described above, the E-fields, including the discrimination of the victim TV antenna and in some cases the polarization, are calculated at each TV antenna and sorted, and the maximum and next-to-maximum (hereafter referred to as "sub-maximum") field strength across the neighboring residences are retained as the output for that trial.[10] Over 25000 trials, a distribution of these maximum values results. An example cumulative distribution is shown in Figure A4. The 90% values of the cumulative distribution are chosen as the values to report. That means that for 90% of the random arrangements of antenna azimuth and location, the E-field strength is below the reported maximum value. For the other 10% of the trials, the E-field will exceed the reported field strength. The choice of the 90% confidence is somewhat arbitrary but seems to be in keeping with the Commission's confidence choices.[11] Obviously, changing the confidence value will directly impact the reported field strength, with higher confidence values yielding stronger field results.

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[10] For example, if eight houses report field strengths of 15, 5, 10, 13, 20, 18, 2, and 6 uV/m for a trial, the values of 20 uV/m and 18 uV/m are retained as the maximum and sub-maximum output for that trial. Actual trials use 24 neighbors (25 total houses including the unlicensed user).

[11] Such as using F(50,90) curves to predict DTV field strength, F(90,90) curves to predict in-contour field strengths for adjacent channel operation, etc.

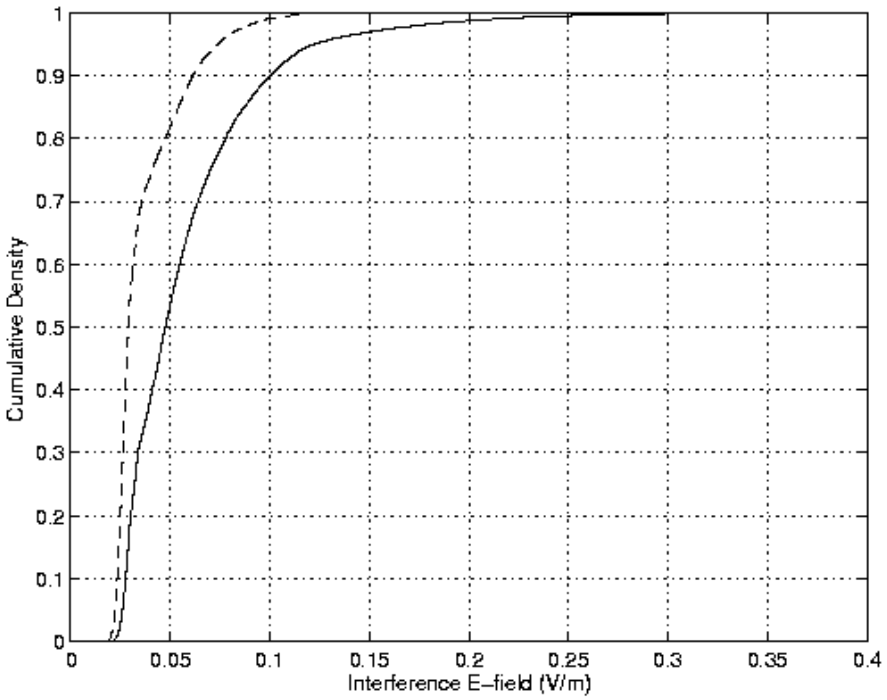

Figure A4. Cumulative distribution for maximum (solid) and sub-maximum (dashed) E-field for normalized 1 W EIRP, H-VHF, and OET-69 unlicensed transmit and receive discrimination pattern. For these curves, the 90% confidence E-field values are about 100 mV/m and 61 mV/m for maximum and sub-maximum, respectively.

The sub-maximum value is retained to gauge the amount by which the maximum exceeds the field at all the other houses. This value may be useful if not all neighboring houses have TV antennas.[12] A simulation that calculated the 90% confidence maximum E-field versus a probability that a house had a rooftop TV antenna was performed. This simulation used a 9 x 5 grid of houses to get more samples for low probability of TV antenna values. The relative results are shown in Figure A5. As an example, if there is only a 5% probability that a house has a rooftop TV antenna, the 90% confidence maximum E-field is 10.6 dB below the 90% confidence maximum E-field over 24 neighbors. As the probability that a house has a TV antenna increases, up to 50% for this simulation, the maximum E-field gets closer to the maximum calculated over all houses, being only 1.8 dB below the 90% confidence maximum over all houses at the 50% probability point. For these parameters, the sub-maximum (plotted as the heavy horizontal line at -4.2 dB) corresponds to the 90% maximum if the probability that a house has an antenna is 23.3%. Since the probability that a house could have a rooftop antenna could vary widely from neighborhood to neighborhood, and since it may not apply on a lot-by-lot basis (e.g., areas without cable service), it was decided to use the sub-maximum rather than assuming a TV antenna population density.

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[12] That is, the maximum E-field strength might occur at a house without a TV antenna, in which case it is not interfering.

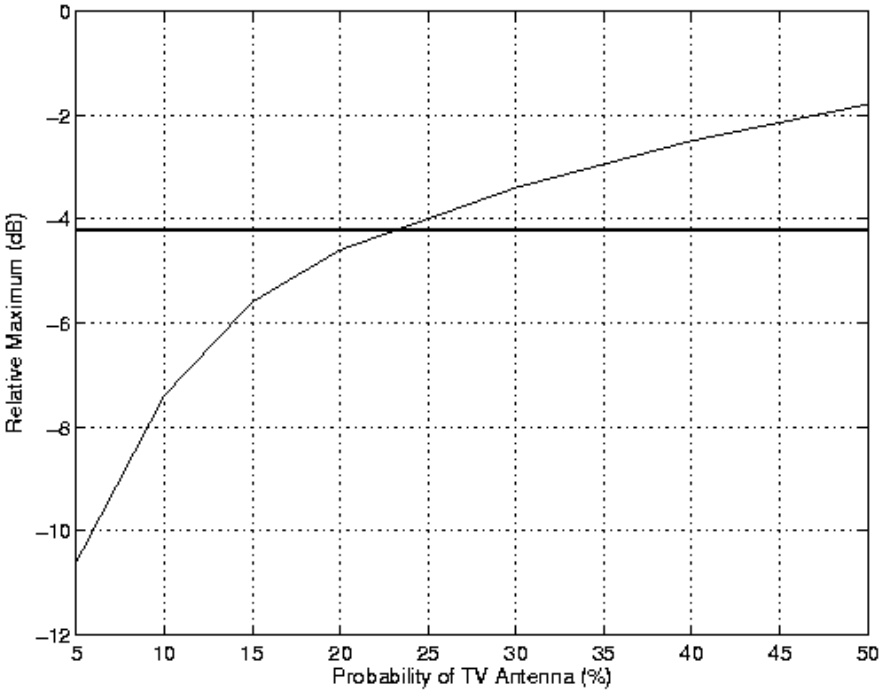

Figure A5. Maximum relative E-field (90% confidence) versus the probability that a neighboring house has a TV antenna. The E-field is compared to the 90% confidence maximum when the E-field is calculated at all neighboring houses. The heavy horizontal line is the sub-maximum (see text). This particular case used OET-69 co-polarized antenna patterns for H-VHF (CASE 2 below).

CASE 1

The first case analyzed used a co-polarized, omni-in-azimuth unlicensed antenna and the reference OET-69 patterns for the TV antenna discrimination. The unlicensed user would likely use some azimuth pattern gain in practice, but since this is not specified in the NPRM it cannot be assumed. Table A4 shows the out-of-band emission (OOBE) EIRP for a Part 15.209(a) emission, the required 6 MHz OOBE EIRP to satisfy the co-channel D/U level to 90% confidence, and the amount that Part 15.209(a) values exceed the required value.

Band	Part 15.209(a) 6 MHz EIRP (nW)	6 MHz EIRP to satisfy D/U with 90% confidence (pW)	Excess EIRP for maximum (dB)	Excess EIRP for sub-maximum (dB)	Excess EIRP from Worst Case Analysis (dB)
L-VHF	180	66.5	34.3	28.6	42.3
H-VHF	405	418.5	29.8	23.8	37.8
UHF	720	1339	27.3	21.1	35.3

Table A4. Required out-of-band emissions EIRP to satisfy co-channel D/U levels for nearest neighbor conditions and omni, co-polarized unlicensed transmissions. Part 15.209(a) emissions are too high by the "excess EIRP" amount.

As can be seen, the required OOBE EIRP to satisfy the co-channel levels for these conditions is still exceeded by around 30 dB (column 4) with Part 15.209(a) levels, but at least the random location and TV discrimination has reduced the excess from the worst-case 10 m analysis (column 6) by around 8 dB. The sub-maximum field value is 5.7 to 6.2 dB weaker than the maximum, and the allowed out-of-band emissions are about 14 dB more relaxed than the value predicted from the worst-case analysis.

CASE 2

For this case, OET-69 patterns were used for both the unlicensed transmitter and the victim TV discrimination. *See* Table A5.

Band	Part 15.209(a) 6 MHz EIRP (nW)	6 MHz EIRP to satisfy D/U with 90% confidence (pW)	Excess EIRP for maximum (dB)	Excess EIRP for sub-maximum (dB)	Excess EIRP from Worst Case Analysis (dB)
L-VHF	180	279	28.1	23.5	42.3
H-VHF	405	2042	23.0	18.8	37.8
UHF	720	6605	20.4	16.4	35.3

Table A5. Required out-of-band emissions EIRP to satisfy co-channel D/U levels for nearest neighbor conditions and OET-69, co-polarized unlicensed transmissions.

The required OOBE EIRP to satisfy the 23 dB co-channel D/U is still over 20 dB below Part 15.209(a) for the maximum E-field house, but at least it is about 15 dB more relaxed than the value calculated for worst-case 10 m conditions, and about 6 - 7 dB more relaxed than the required OOBE EIRP for omni transmit antennas. This indicates that the OET-69 pattern on the transmitter recovers 6 to 7 dB higher EIRP over an omni transmit antenna. The sub-maximum OOBE EIRP values are about 4 dB more relaxed than the maximum.

CASE 3

Since the unlicensed antenna can be more strictly specified than the TV antenna (since it is under the unlicensed system operator's control), a stricter side/back-lobe level can be specified. The actual pattern will depend on the surroundings, but if professionally installed as suggested in the NPRM,[13] the assumption here will be that the pattern will survive installation. For this case then, the side/back-lobe level is specified at 25 dB. This value is somewhat arbitrary but would generally be considered to be representative of a high performance antenna. *See* Table A6 for results.

[13] *See* NPRM ¶ 26.

Band	Part 15.209(a) 6 MHz EIRP (nW)	6 MHz EIRP to satisfy D/U with 90% confidence (pW)	Excess EIRP for maximum (dB)	Excess EIRP for sub-maximum (dB)	Excess EIRP from Worst Case Analysis (dB)
L-VHF	180	301	27.8	23.4	42.3
H-VHF	405	2080	22.9	18.8	37.8
UHF	720	6632	20.4	16.4	35.3

Table A6. Required out-of-band emissions EIRP to satisfy co-channel D/U levels for nearest neighbor conditions and OET-69 mainlobe/25 dB down side lobe, co-polarized unlicensed transmissions.

The OOBE EIRP for the maximum E-field in this case can only be about 0.1 dB higher than that allowed for the OET-69 unlicensed transmit antenna, indicating that there is little advantage gained from additional side lobe suppression if the maximum E-field across the neighboring houses is being retained. This makes intuitive sense since side lobe level doesn't help much if the main lobe is pointing at one of the victim antennas. A narrower main lobe beamwidth might help more than further reduction of side lobes. For the $\cos^4\theta$ pattern the 3 dB azimuth 2-sided beamwidth is about 47º.

CASE 4

For this case, the 90% E-field value is set and the required cross-polarization isolation is calculated to satisfy D/U levels assuming Part 15.209(a) emissions. The cross-polarization isolation is modeled as a lossy unlicensed transmit pattern that is uniformly distributed in loss (for each azimuth angle in each trial) between a specified minimum isolation and some spread of isolation values (here assumed to be 10 dB). This approach is preferred since perfect cross-polarization isolation would result in 100% confidence that the co-channel interference level is satisfied. Of course, perfect cross-polarization isolation cannot be achieved in practice since this depends not only on the cross-polarization isolation of the unlicensed transmit and victim TV antenna construction and design, but also the mounting of those antennas (*e.g.*, whether they are "true" horizontally mounted and "true" vertically mounted) and any Fresnel zone scatters (attic vents, chimneys, or ornamental items such as weather vanes) that can result in coupling between otherwise orthogonal polarizations. The statistics of the coupling between polarizations due to such scatters would need to be determined experimentally. A collection of experimental results would result in a probability density, and some amount of isolation could be determined to satisfy some confidence. *See* Table A7 for simulation results.

Band	Part 15.209(a) 6 MHz EIRP (nW)	Required minimum cross-pol isolation for maximum (dB)	Required minimum cross-pol isolation for sub-maximum (dB)
L-VHF	180	30.4	25.4
H-VHF	405	26.0	20.9
UHF	720	23.3	17.7

Table A7. Required cross-polarization isolation to satisfy co-channel D/U levels for nearest neighbor conditions and Part 15.209(a) unlicensed out-of-band emissions.

From the Table, it can be seen that for example the UHF band, a cross-polarization isolation of 23 – 33 dB (23.3 dB minimum with the assumed 10 dB spread) would be required to satisfy co-channel D/U levels at protected contour field strengths with 90% confidence for the maximum E-field house. The required minimum cross-polarization isolation for the sub-maximum E-field strength is about 5 dB more relaxed over the three bands. Recall that this is a required *system* or *path* cross-polarization isolation; while this range of cross-polarization isolation may be achievable in practice for a well-designed, isolated unlicensed antenna, scatterers or limited cross-polarization isolation in the victim TV antenna can result in coupling between polarizations, especially as noted above if it is not mounted in the true horizontal polarization or if it was an inexpensive or poorly designed TV antenna. While poorly designed TV antennas would likely be inadequate in the assumed TV fringe reception conditions (since protected contour values are used for the desired signal), it is likely not appropriate to impose many restrictions on the incumbent's equipment performance.

V. Conclusions

Cross-polarized unlicensed transmissions would allow Part 15.209(a) emissions levels while still satisfying co-channel D/U levels. However, the required isolation values are high considering the potential for scatterers to couple energy between otherwise orthogonal polarizations and imperfect (in a cross-polarization isolation sense) victim TV antennas. Minimum cross-polarization isolation values in the mid-to-upper 20 dB range would be required if Part 15.209(a) emissions are specified and the maximum E-field across all neighbors is considered. A compromise approach would codify reduced out-of-band emissions, *e.g.*, 10 dB below Part 15.209(a) and relax the cross-polarization isolation into the mid-teens of dB.

If co-polarized unlicensed antennas are used, Part 15.209(a) emissions are inadequate by over 20 dB for the maximum interference field at 90% confidence, and the Commission should codify a maximum azimuth beamwidth and minimum side lobe level as well as stricter out-of-band emissions levels.

APPENDIX B

ANALYSIS OF TRANSMIT POWER OF ADJACENT CHANNEL OPERATIONS WITHIN A PROTECTED CONTOUR

The service contour for a high VHF DTV station is defined by a 36 dBu field strength. At a distance of 10 m away from a TV receiver that is on the fringe of the reception area, an unlicensed device could be radiating on an adjacent channel. This case can also be analyzed statistically as was done for the out-of-band emissions. *See* Appendix A. But first, this worst-case is calculated. For the emissions of the unlicensed device in the upper adjacent channel to be less than 26 dB[1] greater than this 36 dBu field, the radiated power of the unlicensed device would have to be less than:

36 dBu (TV signal) + 26 dB (adjacent channel allowance) = 62 dBu

62 dBu = 1259 uV/m

$$EIRP = 4\pi \cdot (10\ m)^2 \cdot (1259\ \mu V/m)^2/(377\ \Omega) = 5.28\ \mu W$$

or -22.8 dBm, almost 59 dB below the maximum +36 dBm transmitter EIRP for a single fixed/access device. This assumes co-polarized unlicensed emissions. This 5.28 μW is not much power for a fixed/access system and would be of limited utility. Assuming noise limited unlicensed operation, 2 MHz noise bandwidth, 6 dBi receive antenna gain, 10 dB noise figure receiver and a 12 dB C/I requirement, the sensitivity of the unlicensed receiver is

-174 dBm/Hz + 10 log (2 MHz) + 10 dBNF + 12 dBC/I = -89 dBm

and the tolerable path loss would be -22.8 dBm – (-89 dBm - 6 dBi) = 72 dB. With free space path loss and at 200 MHz frequency, this corresponds to an unlicensed link range of only 475 m (about 1558 feet). With 10 dB of fade margin, this would be reduced to 150 m (or about 500 feet).

The nearest neighbor statistical methodology for fixed/access rooftop antennas can also be applied to this analysis. Considering Case 2 with co-polarized OET-69 azimuth patterns for both the unlicensed transmit and victim TV receive antennas, and the 5 x 5 grid layout, the values in Table B1 result.

[1] *See* NPRM ¶30 (Table).

Band	Maximum E-field (dBμ)	Allowed EIRP for maximum E-field (μW)	Allowed EIRP for sub-maximum E-field (μW)	EIRP for worst-case 10 m spacing (μW)
L-VHF	54	25.7	63.9	0.836
H-VHF	62	162	422	5.28
UHF	67	512	1334	16.7

Table B1. Allowed EIRP to satisfy -26 dB D/U ratio with 90% confidence for DTV assuming OET-69 azimuth antenna patterns for the unlicensed transmitter and TV discrimination.

With the OET-69 patterns and random location/azimuth, the allowed EIRP for the maximum E-field to satisfy the D/U ratio with 90% confidence is 14 to 15 dB higher than allowed for the worst-case 10 m analysis. For the sub-maximum E-field, the allowed EIRP increases to about 19 dB higher than allowed for the worst-case 10 m analysis.

The same analysis was performed for cross-polarized unlicensed transmissions with 10 dB minimum cross-polarization isolation and 10 dB isolation spread. The same -26 dB D/U ratio and 90% confidence values were used. The results are shown in Table B2.

Band	Maximum E-field (dBμ)	Allowed EIRP for maximum E-field (μW)	Allowed EIRP for sub-maximum E-field (μW)	EIRP for worst-case 10 m spacing (μW)
L-VHF	54	130	412	0.836
H-VHF	62	815	2662	5.28
UHF	67	2648	9726	16.7

Table B2. Allowed EIRP to satisfy -26 dB D/U ratio with 90% confidence for DTV assuming 10 dB minimum cross-polarization isolation for the unlicensed transmitter and OET-69 TV discrimination.

A cross-polarization isolation of 10 to 20 dB allows roughly 22 dB higher EIRP for the maximum E-field condition and 27 to 28 dB higher EIRP for the sub-maximum E-field to satisfy the -26 dB adjacent channel D/U ratio with 90% confidence. Even with cross-polarized operation, the highest allowed EIRP to satisfy the maximum E-field D/U ratio in the adjacent channel allows only about 2.6 mW of EIRP, over 31 dB below the maximum +36 dBm EIRP allowed for fixed/access devices. Analyzed another way, an additional 31 dB of cross-polarization isolation would be required to allow full power emissions.

The last case analyzed here is the omni-in-azimuth co-polarized case. This one is analyzed last here to tie it in with portable operation (since portables would be expected to have near-omni performance) and the need for adjacent channel constraints for those devices. Table B3 shows the allowed EIRP for this case.

Band	Maximum E-field (dBu)	Allowed EIRP for maximum E-field (uW)	Allowed EIRP for sub-maximum E-field (uW)	EIRP for worst-case 10 m spacing (uW)
L-VHF	54	5.28	19.6	0.836
H-VHF	62	33.2	134	5.28
UHF	67	106.5	412	16.7

Table B3. Allowed EIRP to satisfy -26 dB D/U ratio with 90% confidence for DTV assuming an omni-in-azimuth co-polarized unlicensed transmitter and OET-69 TV discrimination.

This case allows a maximum of 106 uW EIRP for the maximum E-field to satisfy the required D/U ratio. This is almost 46 dB below the full power fixed/access EIRP of +36 dBm, and is 36 dB below the maximum personal/portable EIRP of +26 dBm. The NPRM at ¶31 states, "personal/portable devices would be subject only to the co-channel criteria". However, given the analysis in the previous section, and the limited transmit power levels necessary to respect the adjacent channel constraints, the 10 dB reduction in EIRP for portable transmitters from +36 dBm to +26 dBm does not appear sufficient to justify excluding them from adjacent channel constraints, especially since the portable device can be arbitrarily oriented and cross-polarization isolation cannot be depended upon (*e.g.*, a PDA/phone can go from near-horizontal to near-vertical depending on how it is being used). While the egress losses from indoor operation would help reduce interference, the unlicensed devices are not constrained to operate only indoors, and even so a portable device near a window would experience little loss. Furthermore, look-up angle should not be depended upon for a large amount of TV antenna discrimination. If a portable is at 2 m height and a rooftop antenna is at 9 m height, a portable at a range of 30 m is only 13º below the elevation boresight, which is still likely in the elevation beamwidth of the TV antenna.

As an example, for UHF with its 41 dBu protected contour value and -26 dB adjacent channel D/U level, with

- 3 dB polarization loss,
- 25 m free-space path loss,
- 1.75 dB (36º beamwidth for the OET-69 antenna pattern) of azimuth TV antenna pattern loss for 90% confidence (that is, there's only a 10% chance a portable would fall within the 36º beamwidth, so 90% of the time the pattern loss is higher than 1.75 dB), and
- 1 dB of elevation TV antenna pattern loss,

the allowed EIRP is 392 uW (-4.1 dBm):

$$\sqrt{\frac{392\times10^{-6}\cdot10^{-(3+1.75+1)/10}}{4\pi(25)^2}377} = 2239 \quad \mu V/m = 67 \text{ dBu} =$$

41 dBu protected contour + 26 dB U/D ratio.

The allowed EIRP for L-VHF and H-VHF would be 13 and 5 dB lower, respectively, or -17.1 and -9.1 dBm, respectively.

Conclusions

Considering the potential for adjacent channel interference even with relatively low transmit power, Motorola recommends that all portable devices be subject to adjacent channel level constraints, which the FCC has proposed to apply only to fixed/access devices. A maximum EIRP for these devices would have to be negotiated between broadcasters and unlicensed users based on experimental results in a variety of scenarios, but given the scenarios investigated, Motorola suggests that the maximum EIRP for personal/portable devices operating on DTV adjacent channels will be approximately -17, -9, and -4 dBm for L-VHF, H-VHF and UHF, respectively.